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ABSTRACT

This annual report presents several articles related to the work of the Clinical Center for Child Development at Hokkaido University in Sapporo, Japan. The articles are: (1) "Intrinsic Musicality: Rhythm and Prosody in Infant-Directed Voices" (Niki Powers); (2) "Movable Cognitive Studies with a Portable, Telemetric Near-Infrared Spectroscopy System" (Yoko Hoshi, Shing-Jen Chen, Ai-Qin Liu, and Mamoru Tamura); (3) "Cross Cultural Comparison of Emotion Regulation in Japanese and American 11-Month-Old Infants" (Tatsuo Ujiie, Joseph Campos, Rosemary Campos, Linda A. Camras, Harriet Oster, Kazuo Miyake, Lei Wang, and Zhaolan Meng); and (4) "The Basic Structure of Metacommunication in Intersubjective Fun-Interactions between Mothers and Infants: Analysis of Two Contrasting Cases" (Shigeru Nakano). (KB)

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RESEARCH AND CLINICAL CENTER FOR CHILD DEVELOPMENT

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No.23

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RESEARCH AND CLINICAL CENTER FOR CHILD DEVELOPMENT

Annual Report
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INTRINSIC MUSICALITY : RHYTHM AND PROSODY IN INFANT-DIRECTED VOICES

Niki Powers
University of Edinburgh

Abstract

The theory of musical acoustics and new computerised acoustic analysis were applied to obtain a precise and comprehensive account of parents' vocal communication and it's motivating and regulatory potential in the first year of life. Infants' sensitivity for the rhythms and melodic or prosodic features of adult vocalisations, i. e. their adaptations for 'Communicative Musicality' (Malloch, 1999) was studied, with particular attention to responses to infant-directed forms of maternal vocalisations (speech, song and sound games) in which rhythmic expression and affective quality are enhanced.

Seven mother-infant dyads were filmed in their own homes, every two weeks for three months. Mothers were instructed to play with their infants as they normally do. The pairs were filmed, and DAT recordings were made of each session. Video microanalysis using a well-established category system (Trevarthen and Marwick, 1982) was carried out on segments of video, to elucidate the nature of the infants' non-vocal communicative behaviours and how these developed over time. Inter-rater reliability was established at 87.8%. Acoustic analysis was carried out on corresponding segments of DAT tape, using Hypersignal computer software to produce spectrographic and fundamental frequency pitch information (Malloch et al., 1997). This gave a comprehensive description of the vocal behaviours of both mothers and infants and the overall temporal coordination of their interactions. It also allowed a preliminary examination of how mother and infant vowel sounds are placed in the overall structure of the interaction. Mother and infant vowel sounds were further analysed using Praat Linguistic software. Small segments of vowel sounds were copied into the Praat software program and subjected to a formant analysis. Structural differences were noted.

The descriptions that were gained using this method showed that mothers and infants both actively participate in adapting and regulating their communicative interactions.

Preliminary vowel analysis showed that vowels play a key role in temporal ordering and expression and perception of emotional affect of both partners.

Key Words: musical acoustics, communicative musicality, rhythmic expression, emotional affect

INTRODUCTION

Research with infants has over the last two decades provided a fascinating insight into the foundations of communication. However, many questions still remain and there

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is speculation and controversy over the precise nature of features underlying what we understand so far about these foundations.

The problem is undoubtedly a complex one, but has relevance for researchers in many fields within psychology. What we are communicating contains several features alongside our semantic message. One important feature of all communication is the emotional affect, and research into infant communication has led to interesting conclusions about the systems within the human brain that allow us to communicate, first our emotional, and second our semantic messages. If research can establish how infants produce communicative behaviour from birth, how they can perceive communicative behaviour directed to them from others, and what communicative features they pay attention to, this will advance our understanding of the higher cognitive processes of language comprehension.

More recent research with infants has uncovered evidence to support that neonate communicative systems are functioning in an organised way. It is accepted that there is some kind of temporal 'sense' to what infants perceive and react too. Wittman and Poppel (1999) present evidence for two fundamental levels of temporal processing in the Central Nervous System. A high frequency level operating around a 30ms time interval provides information about temporal order and control. A low frequency level, operating around a 3s interval, combines smaller, high frequency components into comprehensible units. However, underlying features of this temporal processing are elusive, mainly because they are so complex in their nature. Wittman and Poppel (1999) propose that high frequency temporal processing is evident in action and perception tasks, and suggest that this may be evidence for a 'neuronal clock', possibly situated in the left cerebral cortex and operating throughout communicative, perceptual and motor domains whenever precise central control is exercised in action and experience.

Infants, even in the early weeks, have the capacity to attend to the parental language over others and they can distinguish languages of the same type as their own from those of a different type; for example, differentiating stress-timed and syllable timed languages. So they are preparing to hear and produce speech. They are not just reacting to random events or practising making sounds. Nevertheless, the full extent of infants' adaptations for hearing and acquisition of language is not known. It is still not clear what the specific underlying features are, that attract infants' interest, and prosodic regularities are extremely difficult to pin down.

By exploring different levels of phonetic and intonational expression in infant-directed speech, linguists have recently make significant advances in understanding the 'intuitive parenting' of speech to infants (Stern et al., 1982). Understanding the way that communicative information is processed gives only part of the picture. Communicating humans are not only selectively processing information, they move voluntarily and often reacting with irrational intuition. Human motivation and levels of ability and interest seem to have an important effect on the development of underlying communicative features.

There is a growing realisation, mainly as a consequence of descriptive analysis of parents' vocalisations and of infants' attention to their imitations, and practice to themselves when alone (self-imitations), that the foundation is built on intuitive motives of

infants, which parents match and support, and particularly on shared rhythms of expressive action, and emotional qualities in vocal, facial and gestural expression (Hubley and Trevarthen, 1979; Trevarthen, 1999, 2000). Malloch et al's Communicative Musicality (1997) is an integrated theory to explain these 'motive co ordinations' in infants and parents. It uses musicological descriptions of mother infant vocal interactions to precisely characterise the inherent foundations of human consciousness, action and thinking that enable an infant and an adult to coordinate in a coherent flow of expression.

Communicative Musicality

The Communicative Musicality Model (Malloch et al., 1997, Malloch, 1999; Trevarthen, 1999, 2000) offers the potential to examine underlying features of vocal communication between mothers and their infants. This method generates a visual description of acoustic parameters. Specific features such as pitch, loudness, quality and timbre are shown graphically as a function of time, and temporal patterns can be measured. Using this method, researchers are beginning to answer some of the questions about underlying features of communicative behaviour. Malloch et al (1997) found that the musical qualities of 'pulse', 'quality' and 'narrative' were utilised by a mother and her 6-week-old infant throughout their communicative interactions, to coordinate and regulate emotional affect. Further examination confirmed that communicative interactions between mothers and their infants are highly organised and closely coordinated.

Co-ordinated communicative interactions are evident in infants from birth (Trevarthen, 2000). Newborn infants show an intuitive preference for and are regulated by, the maternal voice (De Casper and Fifer, 1980; Fifer and Moon, 1995; Spence and Freeman, 1996). Early acoustic encounters have been shown to have an effect on infant perception that is especially relevant when they are being exposed to language (Kuhl, 1998). What is still unknown, are the specific features of the maternal voice that attract the infant's attention and how these characteristics are utilised by both mother and infant to coordinate their affective expression. Although many details are being discovered, the processes involved are complex and a lot of research is still needed.

Stern et al (1982) demonstrated that American English-speaking mothers employ particular intonation contours in specific interactional contexts, when communicating with their 2-month-old infants. Mothers used rising intonation contours to encourage interpersonal contact with their infants and sinusoidal and bell-shaped intonation contours to maintain a positive emotional state in the infant. It appears that maternal intonation contours are marking suprasegmental features for the infant and they are teaching the infant context-specific patterns of communication.

It is well established that pitch range is greatly expanded in maternal speech (Stern et al., 1982). Salient features are exaggerated by the parent, which makes them perceptually attractive to the infant. Some features of maternal intonation contours appear to be critical in the regulation of infant affect. Mothers will produce context-specific intonation curves over bipolar dimensions of affect when communicating with their 2-month-old infants, in both tone languages such as Chinese Mandarin and stress languages such as American English (Papousek and Papousek, 1991). This suggests that, at least some features of maternal intonation are used across languages to regulate emotional affect in

infants. The problem is, that this is only one tiny piece of the puzzle and the underlying features of the specific intonation contours discussed here, are still not fully understood. What is it about such intonation that provides the vital information to the listener about the speaker's affective message?

Shimura and Imaizumi (1995) found that two-month-old Japanese infants modified aspects of the fundamental frequency in their utterances to express emotional affect. The infants manipulated the fundamental frequency range, intonation contour shape, vocalisation length and altered the number of segments in their vocalisations to express specific emotions. These researchers found that mothers appropriately interpreted the infants' emotional expressions. The mothers responded to the infants based on their interpretations and according to the context, and in this way the infant learns the function of language.

It is accepted that there is co-ordination of structural features of communication, such as fundamental frequency, duration, loudness and pitch, but it is not known how these properties interact. Difficulties lie in the complex involvement and co-ordination of different structural properties of the sounds in speech. An added difficulty is that perception of communication and language involves a great deal more information than is available from the acoustic signal alone (Kuhl and Meltzoff, 1982; Harris et al., 1986; Heinmann, 1998; Papaeliou, 1998). The human infant is born with the motivation for intersubjective communication with others on a multi-model level. Trevarthen (2000) puts it well when he says that infants are "born for a new kind of brain-to-brain interaction and for a unique capacity for cultural learning" (p14). Motivation, and the emotional intention that it induces, are the driving forces for infant attention, perception and action.

Motivations and Meaning

Aitken and Trevarthen (1994, 1997) describe the development of neural systems for the motivation for intersubjective communication in the brain of the human foetus. The neonatal ability to communicate sympathetically with other people is founded on a biological substrate of behaviour. The intrinsic motivation to communicate develops, in a sense, from the inside out (Trevarthen and Aitken, 2000). Newborn infants are innately motivated to "employ poly-rhythmic expressiveness in synchrony with the care and support of their parents to learn the signs of communication in a particular culture" (Trevarthen, 1999, p174). They are born to communicate and to learn.

The musical features of infant-directed speech are known to be perceptually attractive to infants. Infants can discriminate temporal patterns, harmonic intervals, loudness and voice quality (Chang and Trehub, 1977; Chang and Trehub, 1977; Trehub, 1987; Trehub et al., 1993). They show a preference for communication pitched at 262 Hz, which in musical terms is a middle C (Trehub, 1990), and they can differentiate between intonation contours (Papousek, 1996). They do not discriminate on the basis of individual factors; rather their discrimination is based upon individual features in relation to the surrounding features (Cohen et al., 1987). Music and Language are human artefacts and they are both built upon re-occurring patterns (Martin, 1972; Hofstadter, 1985). These patterns range from the simple, as is optimal for infant-directed speech and song (Trehub,

1990; Trainor, 1996), to the highly complex, such as the regulation of grammar. These patterns are predictable, they have a beginning and an end, and they allow humans to formulate meaning from acoustic streams of information.

Friederici and Wessels (1993) found that 9-month-old infants show a preference for certain phonotactic patterns that provided information on word boundaries, when words were presented, embedded into a context of similar words. In another experiment these researchers filtered phonotactic information from the speech sample, whilst leaving prosodic information intact. They found that the infants showed no preference for the specific word boundaries. They conclude that it is phonotactic information that provides information to the infant listeners about the prosodic features. Phonotactics are the particular sequences of sounds that are evident in any given language (Crystal, 1992), in other words they indicate the relationship of different aspects of patterns in speech. Other researchers have emphasised the influence of preceding and following sounds, on the sound to be perceived or produced (Chang and Trehub, 1977; Trehub et al., 1987; Ladd, 1996). When trying to uncover what features of sound infants are attending to (or producing), it is important to consider contextual information.

Communication occurs between people and as well as structural information about sound, there is also an interaction between contextual factors and motivation. The co-ordination of motivation and communication has been shown to play a central role in mutually satisfying communication between parents and their infants (Papousek and Bornstein, 1992; Papaeliou and Trevarthen, 1994; Reddy et al., 1997). It has been shown that there is some regularity in parent-infant envelopes (Jaffe et al., 1999). They are dynamic, constantly changing and regulated by both partners depending on what they feel and what they want to express (Beebe et al., 1982; Beebe and Gerstman, 1984; Beebe et al., 1991; Papousek, 1992; Fernald, 1992).

If the patterns underlying early communicative behaviour can be teased apart, developmental, neuropsychological and cognitive research will benefit greatly. It would provide evidence about what is innate and it can give clear information about what processes are going on at different developmental stages. It could facilitate in understanding whether the brain is firing to separate, distinctive aspects of the overall temporal pattern and if so how these aspects are communicating with each other.

Als (1995) suggests that communicative development is linear. She describes the premature infant as "neurodevelopmentally expecting three securely inherited, evolutionarily promised environments in support of their appropriate development, namely, their mother's uterus, their parent's bodies and their families community and social group" (p440). She states that, the older the infant is when born, the higher the infants' scores will be on attentional, motoric and regulatory organisation scores. This research with premature infants suggests that the full term infant will have an optimal 'expectation' of specific communicative features occurring in their environment.

THE PRESENT RESEARCH

The theories mentioned above and the research behind them shows that communicative systems are organised behaviourally and perceptually. They give much needed detail about how the mechanisms are expressed. However, many questions still remain about

how prosodic features of language are developed and maintained. The present research hopes to carry out a preliminary study of the part that mother/infant vowel sounds have in relation to temporal and prosodic information.

The theory is proposed that phonological and prosodic features of vowels mark primary elements of the co-ordinated and musical interactions that are evident between parents and their infants. There are several reasons for believing that vowels may be marking temporal pattern for infants. They are among the first canonical sounds to be produced by an infant (Locke, 1993 ; Oller, 1986 ; Trevarthen, 1999). Vowels are one of the salient features of speech (Ladd, 1996). Vowels have more extensive harmonics (formants) and infants show a poorer performance on perceptual tasks when harmonic information is limited (Clarkson et al., 1996). It is possible that infants may be drawn to vowel sounds because they are rich in perceptually attractive information. A sensitivity to vowels would correlate with the preference infants show for the affect content of infant-directed speech (Kitamura and Burnham, 1998b).

Vowels play an important part in determining the next sound to be made and in intonation (Ladd, 1996). In this way they are relevant for affect and emotional expression and in the overall narrative of any interaction as well as the articulation of speech. The present study presents this theory in its embryonic stages and provides a brief introduction to further (more extensive) research aimed at establishing precise vowel placement information in speech and singing to infants. Thus the research presented here concentrates on a detailed description of the normal parent-infant interactions in which the vowels are placed in a rhythmic frame.

Theory of Analysis

An analysis of the musical nature of parent-infant communication will provide a basis for continuation of the project to establish the part that vowel sounds play in the expression and perception of emotion and motivation that is central to any mutually satisfying interaction. It will also illuminate the child's path to hearing and producing speech and language.

The pulse / beat, and regulation of rhythms especially duration of seperated phrases will be examined using a combination of methods (discussed above) that have already proved constructive in infant studies. This will provide a necessary backdrop for future research into the placement of vowels in communicative interactions produced by English-speaking and Japanese-speaking parents and infants. A small selection of Short (< 200ms) and Long vowels (200-500ms) will be distinguished and measured with Linguistic software as a test of the proposed method. Spectrographs will act as time maps, showing visually the narrative forms with their expressive changes. These will provide basic data for detailed description of the vocal data.

The pre-semantic envelope and non-referential narrative or drama will be examined using a combination of video microanalysis and acoustic and linguistic methods. Transitions of excitement or tension in segments of spontaneously-produced, contextually relevant speech and nonsense vocal games with and without body movement will be studied to see how parentese in ordinary playful or comforting chat act to 'regulate' infant's emotions. Video microanalysis will be combined with the spectrographic investigation to

give a comprehensive description of the some of the ways in which communication is co-ordinated and regulated over time.

Research Aims

(1) To provide a precise description of normal parameters in samples of good vocal communication between mother and infant, during interactions, in songs, or rhythmic games.

(2) To collect evidence of features of mother's voice and expression and of infant's response that may be universal, looking especially at the rhythmic/narrative structure and acoustic patterns.

(3) To determine some of the ways in which the mother gives affective emphasis to the content of her speech and song.

(4) To establish the temporal pattern of vocal and non-vocal communicative interactions and provide a methodology that will form the basis of future examination of the timbral aspects of vowel structure and vowel placement in the rhythmic structure of the overall narrative in mothers ' talk to infants.

Predictions

(1) I predict that an examination of the normal parameters of good communication will show that a mutually satisfying interaction will be built upon the features of musicality as described by Malloch (1999).

(2) I predict that there will be a variety of phonological and prosodic features that are salient to the infant and manipulated by the parent that will be recognisable in all healthy interactions. This suggests some universal features that will be the focus of future study with English-speaking and Japanese-speaking parents and infants.

(3) I predict that there will be co-ordinated temporal regulation of communication between mother and infant. It is expected that future study will reveal that both in the mother's speech and in the infant's imitative vocalisations, presentation, synchronisation and imitation of vowels will play a major role in marking the temporal patterning of phrases in interactions, and show how they will be used as a principle means by which temporal aspects of expression of emotional affect is regulated both by parent and infant.

METHOD

Subjects

Seven mother-infant pairs volunteered to take part in the project. They were informed that the study was for the purpose of gaining a description of parent-infant vocalisations. All of the mothers were English-speaking and they all lived with their husbands or partners. Confidentiality was assured, and the mother's written permission was obtained for using film and DAT recordings of their interactions for research purposes. Mothers were given a copy of their own video to keep.

Each pair were filmed and recorded once every two weeks over a period of three months. Due to illness and holidays, filming/recording sessions where not always every 14 days. The range of difference in time between filming is shown in figure 1 below:

Filming sessions took place in the mother and infants ' home. They were arranged

Table 1 Infant Identification Code and Gender.

JAK	HO	IS	JAN	RO	AI	LI
MALE	FEMALE	MALE	FEMALE	FEMALE	MALE	FEMALE

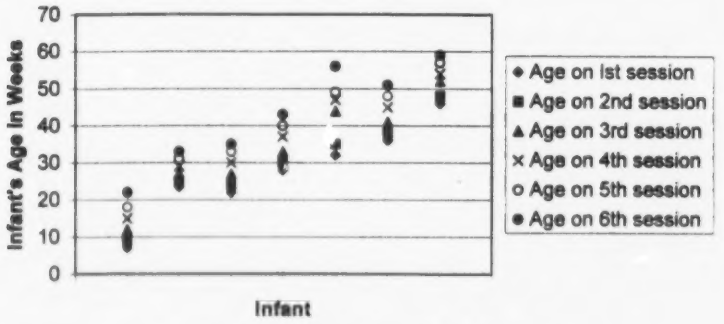

Figure 1 Age of Infant at each filming session.

to be at a time when each infant was rested and had been fed. Recording equipment was set up and the mother and infant were given time to habituate to the camera. They were asked to play as they normally would. Each session lasted for 20minutes.

Analytic Procedure

All of the videos were first pre-viewed in their entirety to get an idea of the relationship between each mother and her infant. The events during each session were noted. Special attention was given to the points at which the infants vocalised. One-minute segments were chosen from each session, for each mother-infant pair. The segments contained samples of spontaneous communicative interaction, and either child-directed song or rhythmic vocal play. The main criterion for inclusion of a segment was defined as a period during the session where both partners are contributing vocally. Where possible recording of each segment was initiated at the beginning of a 'narrative event' that contained vocal contributions from both partners. A narrative event is a sequence of actions or behaviours that can be perceived as having a beginning, middle and an end. Recording was stopped after one minute.

Microanalysis of Video Data

Microanalysis of the video data was carried out to examine unambiguous, verbally defined categories for the infants. Co-ordinated expression, movement and affect were the main parameters for close examination. A validated category system (Trevarthen and Marwick, 1982) was used. The use of this system allowed detailed description of the communicative behaviours that occurred between each mother and her infant over the three-month period.

A one-second time-interval was the unit of microanalysis. Behaviours were coded and graphically represented for each infant. A behavioural category was defined as occurring when it was evident for at least 500ms. To ensure that coding was valid, a researcher who was unfamiliar with the Communicative Musicality Model and who is from

an entirely different theoretical discipline (Business Management) was given a short training session in the coding system. The system was demonstrated once to the volunteer, and then she practiced several times asking questions until she felt confident that she understood the categories and familiarised herself with the equipment. She was then left alone to re-code samples chosen at random. She coded 15% of all data sheets and scores for each sample were compared, the mean of all scores was calculated and inter-rater reliability was established at 87.8%.

Acoustic Analysis

Acoustic analysis was carried out on the initial segments of the first session recorded for each infant, to make clear how the mother is giving emphasis to the affective features of her communication. Only the first segment was used in this initial test of the method. The idea was to separate temporal features (rhythm) from pitch and quality and to chart the development of narrative progressions in expression. To do this, corresponding DAT recordings for each segment were transformed into wave files and then recorded onto re-writable CDs to allow the sound files to be easily transportable and as a means of managing the large files involved. Wave files were created using SoundForge 4.5 PC software. This software allows the sound file to be analysed whilst it is being listened to.

The wave files were then analysed using Hypersignal PC software (Malloch, 1997). This software is based on methods described by Brown (1991, 1992) and it produces spectrographs of the acoustic data permitting segmentation of temporal features from pitch and quality. This gives a clear picture of how the mother is giving emphasis to affective features of her communication (bridge between speech and song) and enables a clear description of the overall rhythmic structure of the interactions.

Linguistic Analysis

Spectral compositions of the vowels produced by both mother and infant were compared with the aid of Praat software. Strong-weak syllables (were the stress is on the consonant and the vowel is weaker) or single vowel sounds taken from the chosen segments were subjected to a primary pitch, intensity and formant analysis.

The present study provides a brief introduction to formant analysis of the vowel sounds. Analysis of formant patterns (especially patterns found in fundemental and first formants) is useful because it is information provided to the listener in these formants that allows discrimination of vowels and identification of the next sound to be made (Crystal, 1992).

The Praat program applied a spectro-temporal analysis using parameters of time step (in the present case this was set at 0.01sec), maximum number of formants (this was set at 5, the normal adult range) and pre-emphasis frequency (50 Hz). The latter is an algorithm that calculates the value of each sample period of sound to reflect (and in relation to) the sound sample before it. This program was used to look at mother's imitations and matching of infant vowel sounds enabling an examination of the quality aspect of the sound.

RESULTS

General Findings

A detailed case study was built up for each mother and her infant. This allowed a precise description of vocal and non-vocal communication for each pair. A small sample of the data will be used to illustrate the findings.

Table 2 below, shows the overall cumulative frequencies of communicative behaviours shown by video analysis for each infant, over the three months of the filming period. Table 2 shows that negative arousal states, avoidance, self-directed behaviours and recalcitrance decrease as the infants' ages increase. Playful behaviours involving objects, such as co-operative games, increase with the age of the infants. Table 2 also allows a comparison between individual infants.

It is important to mention some general points for consideration. During data collection some 'expectancy effect' was evident in the subjects' behaviour. Mothers often worked quite hard to elicit vocalisations from their infants and expressed concern if

Table 2 Overall Frequencies of Video Analysis Behaviours.

Behavioural Categories	Infants (Age range in Weeks)						
	JAK	HO	IS	JAN	RO	AI	LI
	(7-22)	(23-33)	(22-35)	(28-43)	(32-56)	(36-51)	(46-59)
arousal 1	50	17	43	37	12	4	
arousal 2	200	303	317	323	341	356	359
arousal 3	59	40			4		1
arousal 4	19				3		
positive affect	160	323	326	326	342	360	356
neutral affect	165	16	28	30	11		4
angry					2		
anxious							
sad	24	11	5		5		
attend face	57	31	52	46	54	30	47
attend hands	263	312	285	294	301	330	309
avoid	30	17	23	11	5		4
playful	164	338	329	339	342	360	354
recalcitrant	175	22	22	21	18		6
utterances	46	57	69	87	63	58	75
prespeech	24	109	69	75	155	94	132
exploratory/performative	162	341	317	315	356	356	352
self-directed	2	9	53	36	14		
imitates		4	3	3	12		
try			2	1	25		
track		148	150	102	80	149	156
reach/hunt	31	238	239	121	154	222	194
prereach			1				14
cooperative transfer				1		6	6
cooperative game			6	58	38	44	94

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their infants were quiet. This, however, did not cause them to deviate greatly from their normal communications with their child. All of the mothers demonstrated joy and fascination when their infant smiled or made any other overt communicative gestures, whether they were being filmed or not. The mothers seemed to grow less aware of the camera over the time of filming (none of them felt comfortable singing in the first session), whereas the infants seemed to become more aware of it.

Although the mothers had individual differences in parenting methods and styles, they all shared some general similarities. They all adopted the characteristics of motherese 'infant-directed' speech. They exaggerated their intonation, and pitch range and they used simpler words that they repeated often. They all gave verbal explanations of their own actions and the actions of their infants. All of the mothers demonstrated actions and the use of toys for their infant. They exaggerated and slowed down their movements, often vocally producing the noise made by the animal or toy. They all asked their infants questions for example, every mother asked their infant at some point during the filming "are you telling a story?" and many other questions were asked to enquire about what the infants were doing at that point, giving insight into the mothers' interpretations of the infants' actions and affective states.

All of the mothers gave constant assessment of or investigation into their infant's motives and emotional states, and they changed their communicative patterns to maintain a positive affective balance. Most of the time the mother's attribution of an emotional state appeared to be appropriate and it seemed that the infants were skilled in regulating their mother's attention depending on their emotional needs at any given time. The type of instruction/communication changed as the infant developed.

All mothers imitated the vocalisations made be their infants. That is, they matched the sound, sometimes exaggerating it (by lengthening the vowel sounds) or repeating it several times. They also imitated facial expressions, hand gestures and actions. The infants produced language specific stress patterns and preliminary formant analysis indicated that there are interesting structural properties of their utterances, that change over time.

All of the infants had individual differences in behavioural patterns and personalities, but they also demonstrated similarities in some features of their communicative attempts. For example, they all exhibited a sense of humour. They all performed for the researcher, showing off their tricks, smiling and flirting. They all developed an overt interest in the camera and recording equipment as the sessions went on. All of the infants produced avoidant behaviour when the mothers' responses were non-contingent.

Both mother and infant altered their communication depending on how they felt, for example if they were tired. All of the mothers spent time just quietly watching their infant chatting or playing and they all smiled whilst doing so. The mothers varied as to how much time they spent doing this, some hardly did it at all while others spent long periods during the filming session quietly watching their infant. This was particularly evident as the infants got older and began to show more autonomy and interest in objects.

There was a lot of evidence to suggest that communicative behaviours were temporally organised. Communicative behaviours do not remain rhythmically constant. They appear to form a dynamic, functional system that is adapted and regulated by both mother

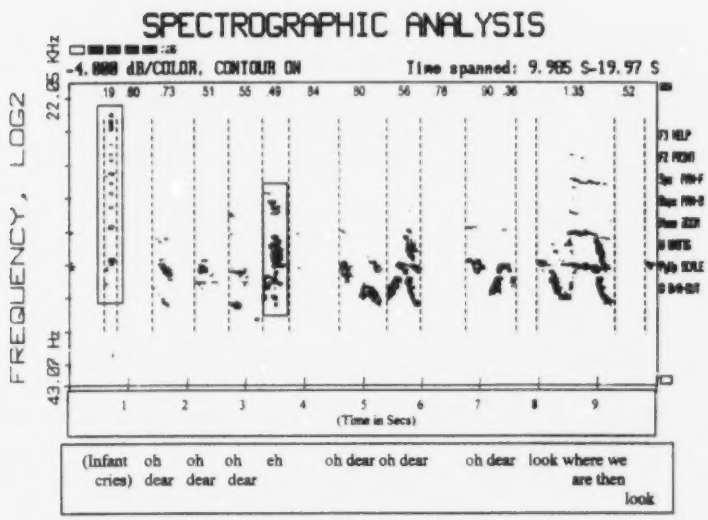
SPECTROGRAPHIC ANALYSIS
-4.000 dB/COLOR, CONTOUR ON
Time spanned: 9.985 S-19.97 S
FREQUENCY, LOG2
22.05 KHz
43.07 Hz
(Time in Secs)
(Infant cries) oh dear oh dear oh dear eh
oh dear oh dear
oh dear look where we are then look

Figure 2 Spectrographic Analysis for JAK.

and infant, to express and maintain positive emotional affect. Complete spectrographic analysis was carried out for each mother and child. Spectrographic examples are shown below. Temporal patterns were measured and are shown by the vertical lines. Infant vocalisations are marked with boxes.

The spectrograph shown in figure 2 gives an example of the temporal regularities found in all of the communication that was examined. This spectrograph shows communication between a mother and her 7-week-old son. The infant cries and the mother uses a repeated intonational pattern to try and sooth her infant. Her overall temporal pattern has many regularities and her intonation contour falls to indicate completion of each unit in the sequence. The infant's cry and his vocalisation (in the first 4 seconds of the spectrograph) when combined measure the same as the mother's general pattern. This indicates that he has some representation of the temporal pattern established earlier in the interaction by his mother and has some ability to match it. His mother has established her temporal pattern in an effort to maintain positive affect in her son. She repeats a simple pattern, producing combinations of rhythmical units in response to his emotional message. The temporal pattern is formed around pauses and vocalisations and it appears that both mother and infant vowel sounds give saliency to the rhythmical units of the interaction.

Figure 3 shows a 23-week-old infant vocalising with her mother. The spectrograph shows how vocal communication for this mother-infant pair is structured around a rhythm that is established by the mother making clicking noises with her tongue. The infant vocalises in the third second of the spectrograph, producing a vowel sound with recognisable formants. Her temporal pattern is a division of the pattern her mother sets and her intonation falls slightly at the end as if to complement the rhythmical structure that is already established. When the infant vocalises, her mother leaves a pause of the same length as the infant's vocalisation and then in the fourth second of the spectrograph she produces an extended vowel sound, also recognisable by its layers of formants. The

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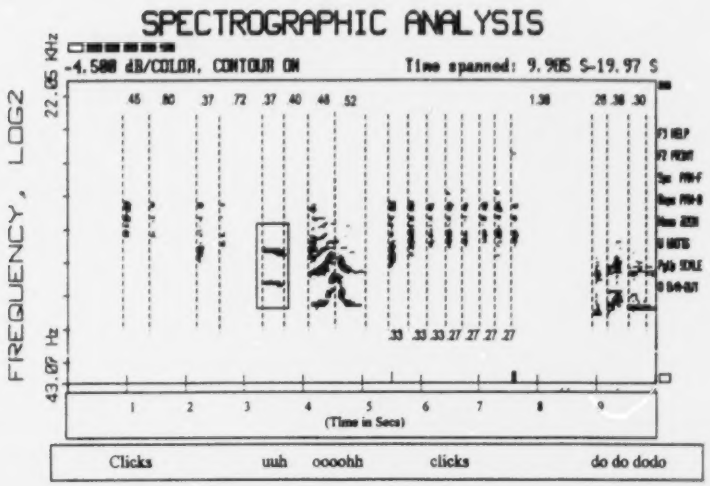

Figure 3 Spectrographic Analysis for HO.

mother's vocalisation takes the form of a reply to her infant's sound and it matches the frequency of the infant's sound.

The preliminary analysis of vowel sounds suggested that vowels are placed at key points throughout the overall speech stream. Mothers lengthened their vowel sounds and when their intonation was exaggerated, it was the vowel sounds that provided the basis for this exaggeration. Infants produced strong vowel sounds that were strongly associated with the expression of emotional affect. However, a comprehensive examination showing the exact phonological and temporal information is beyond the scope of the present research and it is hoped that this will be examined in future research with English-speaking and Japanese-speaking dyads.

DISCUSSION

The findings of the present research support many of the theories presented in the introduction. In particular, the Communicative Musicality Model (Malloch, 1997, 1999) is shown to be a viable and useful method that has potential use in both descriptive and quantitative research. The present research also confirms Malloch's findings that the mothers are acting to maintain a " balance in their joint exploration of pitch space " (1999, p40).

Imitation of infant vocalisations was evident in all of the mother-infant pairs in the present study. This was independent of the infant's age and was apparent in all of the sessions. The mother's imitations of the infant's vocalisations appear to have some kind of representational purpose. Exaggerations and repetitions reinforce the original sound to the infant and this often resulted in the infant attempting to make the same sound again. The infants sometimes imitated the mother's exaggeration of their original sound. This may in some way strengthen neural connections that help them to establish language specific stress patterns in a simple (syllabic) form in the infant's brain.

Research by James Morgan (1995, 2000) demonstrated that infants who were

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exposed to English between the ages of 6 and 9 months, showed a preference for the strong-weak stress pattern characteristic of English prosody. The infants showed this preference for both syllabic and word boundaries. Before the age of 6 months, Morgan found that the infants showed no preference. Cutler (2000) also found that infants had no preference for language-specific prosody before the ages of 6 months. Her work was a part of an international project that aimed to give description of the 'Music within words', comparing prosodic features in Belgium, Canada, France, the Netherlands, Spain and Britain. In an interesting experiment she filtered the acoustic signal presented to infants, leaving only prosodic information. Infants around the age of 9 months continued to show a preference for their mother tongue. Cutler concluded that infants are relying on prosodic features for identification of boundaries.

Mehler (2000) worked on the same project and he found that French neonates at the age of 3 days could distinguish the prosodic breaks at word level. The infants could detect prosodic features from French and Spanish. Both of these languages have very different prosodic structures. For example, French prosody stresses the last syllable in a word, whereas in Spanish prosody, stress changes with each word (to determine it's meaning) and pitch is also used to mark word endings. Mehler suggests that the neonates have an innate capacity to detect prosodic features of all languages and that some development occurs between the ages of 6 and 9 months that will focus their attention onto specific prosodic features characteristic of their own language.

Research has shown that linguistic experience has placed constrictions on infants' abilities to perceive phonetic constituents of speech (Kuhl, 1998). By the age of 6 months, the infant's brain will have become more selective in the phonetic characteristics that it can distinguish. The present study provided evidence that several factors were interacting at this stage in development. Vocal utterances became more advanced, the infants produced language specific stress patterns, they became increasingly mobile and much more aware of a larger environmental space.

It is during this period that secondary intersubjectivity is developed. The present research provided a wealth of evidence to support the idea that infants begin to take initiative in co-operative games around the age of 9 months (Trevarthen and Hubley, 1979; Trevarthen, Murray and Hubley, 1981). The mothers reacted to this development by taking more of a back seat. They sat quietly watching and smiling as their infants directed the play, demonstrating toys only when requested to do so by the infant, or when the infant was in obvious difficulty. Play with objects became more central in the interactions.

Six-months is also the period when the normally developing infant will begin to 'perform' for others (Trevarthen, 1994). All of the infants in the present study were progressively more interested by the researcher and the filming equipment. For some of the infants the last sessions were characterised by repeated attempts to get close to, and explore, the camera. All of the infants displayed a strong awareness of, and a desire to communicate with, the researcher. They all displayed anxiety when their communicative attempts were ignored because the researcher was too busy filming (or did not want to distract the infant from communication with the mother), and did not respond. As they developed, the infants displayed more flirting behaviour and increased the time they spent

looking at the camera. They often involved the researcher in their games and the researcher in turn, often became caught up in the temporal co-ordination of the interaction. This is not surprising however, and serves as an indication of the infants' desire to communicate (Trevarthen, Murray and Hubley, 1981) and the importance of contingent responses for infant well being (Murray, 1992; Robb, 1999).

All of the mothers in the present study produced more exaggerated intonation when they were talking to their infants and they moderated the timing of their vocal and non-vocal communicative behaviour based on their infant's behaviour. The mothers seemed to work to maintain an optimum level of affect (Malloch, 1999; Trevarthen, 2000).

My findings on vowels are, at present limited and will involve further study before they can be subject to a valid comparison with linguists characterisations of the language as to timing of stresses, vowel complexity, tones and vowels. The present findings provide a lot of evidence to support the idea of Wittman and Poppel's high / low frequency temporal fundamentals. However, the results also suggest that the idea of a neuronal clock is perhaps too rigid a description for the complex processes that are occurring on many levels. Descriptions gained in the present study suggest that various emotional factors have to be taken into consideration. It may be that the 30ms / 3s serves as a common optimum level to which the dyads work to maintain but more detailed description is needed of the dynamics of expression before the coordination of vocalisations in time can be explained.

Questions Still Remainin

Further study is intended to address some of the many questions that still remain. Acoustic analysis needs to be extended further over a wider sample of the present mother-infant communications. A more detailed pitch and timbral analysis is required to understand how maternal vowels are utilised and how this changes with the development of each infant and to reveal the ways in which maternal vowel use changes as the infants get older. Infant vowel production and the ways in which infants manipulate their vowel production to express their affect and to draw their mother's attention to more subtle aspects of their communication, also requires a more detailed examination over time.

Practical Application of Communicative Musicality

There are many practical applications of the Communicative Musicality method. It is a useful tool in many research settings were detailed examination of communicative interactions is necessary. The model allows an objective visual description of normal communication and highlights the complex patterns that create meaning in communication. The method can be usefully applied for determining when there are developmental delays in communicative ability. This method can highlight the precise areas in which an individual may have difficulties and so could be used to look at communication between parents, carers and teachers and the children in their care.

The method has been used successfully, to highlight other difficulties in mother-infant relationships, such as postnatal depression (Murray, 1992; Robb, 1999) and acculturation (Gratier, 1999). The method has shown precisely how communication is altered when the mother's mental health or state of well being is challenged, and this would

allow it to be used in a clinical (preventative and etiological) setting. Those who work in a therapeutic situation where verbal/non-verbal therapies are important (Coulter and Loughlin, 1999) have expressed interest in using the model to gain more understanding of how therapy works, or how it can be improved (Loughlin, 2000).

Conclusions

Conclusions can be drawn about the nature of early communication and the intersubjective foundations for learning meaning and language. Normal interactions between parents and their infants are characterised by complex dynamic interactions between different modalities. These interactions are driven by intersubjective motivation to participate in communication that allows both partners to anticipate the other's motives and allow contributions from both partners

It can also be concluded that the Communicative Musicality Method is a useful descriptive tool. It allows a comprehensive and detailed analysis of acoustic data that is necessary when trying to describe something as rich and complex as communication.

The present findings show that normal mother-infant communication requires both partners to actively assess and regulate the other, on an overall temporal level and at a more specific phonological level.

Acknowledgements

I would like to thank the mothers and babies who volunteered to take part in this study for their cheerful participation and their interest in my study. I would also like to thank my Supervisor Professor Colwyn Trevarthen for his support, his inspirational insights into the subject area and for his sharp intelligence. I am very grateful to Rhys Pendred, Stevie and Joe and to my Family for putting up with my preoccupation with this project.. I would also like to thank Jacqueline Holms who worked efficiently and precisely coding my videotapes. There are many other people (especially in the Department of Psychology at The University of Edinburgh) who supported and advised me during this research project and I would like to say thank you to everyone who helped.

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MOVABLE COGNITIVE STUDIES WITH A PORTABLE, TELEMETRIC NEAR-INFRARED SPECTROSCOPY SYSTEM

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Abstract

Combining a wireless telemetry system and a portable near-infrared spectroscopy (NIRS) instrument, we have developed a novel movable neuroimaging system. The subject carries a miniaturized NIRS instrument (8 x 16 x 4 cm) on the back and NIRS data are sent by a wireless telemetry system to a laptop computer that can be placed distant from the experimental place. This system allows subjects to freely move about even during measurement. We applied this system to measure hemodynamic changes in the right frontal region of six young children (1 to 6 years old) while they were performing a Stroop-like test and/or playing with a jack-in-the-box. The children were relaxed and cooperative when they were studied, a result attributable to the fact that children's motion was not restricted and measurements were performed in an examination room not very different from an ordinary living room. Hemodynamic changes were observed during the Stroop test in children whose task performance was high. Our new system provides promise for cognitive studies on subjects who are difficult to examine with recent sophisticated neuroimaging techniques such as positron emission tomography and functional magnetic resonance imaging.

Key Words: near-infrared spectroscopy, neuroimage, children, Stroop-like test

INTRODUCTION

With the advent of modern neuroimaging techniques such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), a great deal of functional mapping data on the human brain have been accumulated. However, most of these data are on the normal adult brain, while the brains of others such as children, the elderly, and patients with psychoneurological problems have not been fully examined. Although, unlike in PET study, radioactive substances are not used in fMRI study, it

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requires strict motion restriction as in a PET study. To get subjects to participate in a study for long time, therefore, sedation is often required, especially in children, which can cause adverse reactions. Furthermore, the experimental environments in PET and fMRI studies are quite different from the daily one, and subjects mostly find this stressful. To gain further insights into brain functions, therefore, a new neuroimaging technique that is completely non-invasive and does not require strict motion restriction has been desired.

Near-infrared spectroscopy (NIRS) measures changes in the hemoglobin oxygenation state in the human brain non-invasively (Jöbsis, 1977). NIRS has been oriented toward use for clinical monitoring of tissue oxygenation. However, we and others have recently demonstrated that NIRS also has the potential for neuroimaging (Hoshi and Tamura, 1993; Kato et al., 1993). NIRS instruments of several types are now commercially available. Among them, a portable NIRS instrument allows subjects to move about during measurement like portable ECG and EEG instruments. Since data are recorded into a memory card interface in this system, however, they are not displayed in real time. We have therefore combined a wireless system with this portable NIRS instrument so that we can see data in real time at a place which is distant from the subject. It was expected that this NIRS system would enable activation studies on freely-moving subjects. To examine the performance and possibilities of this system, we measured the frontal region in young children while they were performing the Stroop test and/or playing with a jack-in-the-box.

THE PORTABLE NIRS MEASUREMENT SYSTEM

The details of the portable NIRS instrument used here (HEO 200, Omron Ltd. Inc., Japan) have been reported elsewhere (Shiga et al., 1997). Briefly, it consists of a main unit and a probe unit. The main unit consists of a one-chip central processing unit (CPU), a light-emitting diode (LED) driver, an amplifier, a memory card interface, a liquid crystal display, and a power source. The probe unit, molded in elastic black silicon rubber, has a photodiode in the center and two-wavelength (760 and 840 nm) near-infrared LEDs on either side. The distance between the photodiode and the LEDs is 3 cm. By measuring absorbance changes at 760 nm and 840 nm, relative concentration changes in oxygenated (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) are calculated every 0.5 seconds. Although only two wavelengths are used for calculation, the algorithm used here is essentially the same as the one employed in our three-wavelength method (Hazeki and Tamura, 1988). Summation of changes in oxy-Hb and deoxy-Hb provides the relative concentration change in total hemoglobin (t-Hb), which is an indicator of the change in blood volume within an illuminated area. This instrument is connected to the transmitter of a wireless system by an RS-232C cable. The size of the NIRS instrument (8 x 16 x 4 cm) is as small as the transmitter of the wireless system (Fig. 1). These are packed in a small bag which a subject carries on the back. NIRS signals are sent by wireless to the receiver, which is connected to a laptop computer, by which data are displayed in real time. NIRS signals can be transferred to a place at a maximal distance of 30 m outside, but about 10 m in a building.

METHODS AND SUBJECTS

The subjects were six healthy children, aged 1 to 6 years (three girls, three boys). Four of the six children (5 or 6 years) went to a kindergarten associated with the Faculty of Education of Hokkaido University. They had no clinical signs of brain disorders. Parental informed consent was obtained prior to the beginning of the study.

Measurements were performed in a room that looked like an ordinary living room. Examiners were a teacher and his assistant who were familiar with the children. The probe was placed on the medial side of the right forehead so that the right frontal polar cortex was mainly measured. Carrying the bag in which a portable NIRS instrument and the transmitter of the wireless system were packed on the back, children sat on a chair or a couch. The receiver and a laptop computer were placed in an adjacent room, where the children were observed by a closed-circuit television.

The four kindergarten children who could perfectly read Japanese syllabic characters ('hiragana') performed a Stroop-like test. The examiner showed a card in which the name of color was written in 'hiragana' in a different color (e. g., RED written in green ink). Ignoring the words, the children named the colors of the ink as quickly and accurately as possible. They performed the Stroop test twice with an interval of about 15 seconds. As a control study, they read 'hiragana' written in black ink before the Stroop test. Each child was trained to perform both the control task and the Stroop test several times before the investigation.

After the Stroop test, hemodynamic responses to a jack-in-the-box were examined in the four kindergarten children and a three-year-old boy. Rotating the handle of the box produced a melody and a doll suddenly appeared from the box. The examiner or children themselves rotated the handle. The one-year three-month-old girl was monitored only when playing with her mother.

To determine whether changes observed during performing a task were significant, values for oxy-Hb, deoxy-Hb, and t-Hb during the activation period were compared with those during the resting period just before the activation period using paired-t-test for each subject. The degree of changes in Hb oxygenation during the Stroop test was compared with that during the control task by Student's t-test. $P < 0.01$ was chosen as the level of significance.

RESULTS

The examination time was about 30 minutes in all children except the one-year-old infant, who was monitored for about 10 minutes. No children felt uncomfortable during measurements and all were cooperative.

Figure 1A shows an example of NIRS traces obtained from a 5-year-old girl during performing the Stroop test. While reading each character, oxy-Hb and t-Hb increased and deoxy-Hb decreased ($p < 0.001$). Compared with these changes, the first Stroop test caused much larger increases in oxy-Hb and t-Hb and a decrease in deoxy-Hb. These changes did not return to the pre-task level immediately after the cessation of the first task, and the second Stroop test did not cause further changes in Hb. The same pattern of changes was also observed in the other 5-year-old girl. Two 6-year-old boys showed increases in t-Hb and oxy-Hb with a decrease in deoxy-Hb while reading each character

($P < 0.001$). One, whose task performance was poor, showed no change in Hb oxygenation during the Stroop test. The other also showed no significant change in Hb oxygenation during the first Stroop test, in which task performance was poor, while increases in oxy-Hb and t-Hb with a decrease in deoxy-Hb were observed during the second one ($P < 0.001$, Fig. 1B). However, the degree of changes in Hb oxygenation during the second Stroop test was the same as the degree of those during reading.

All kindergarten children but one showed no response to the jack-in-the box. One boy showed increases in t-Hb, oxy-Hb, and deoxy-Hb only at the first trial. But, the following trials did not cause any changes in Hb oxygenation. They said that they had not been startled. In contrast, the three-year-old boy showed rapid increases in deoxy- and t-Hb when responding to the jack-in-the-box, while a significant increase in oxy-Hb was not observed (Fig. 2). Similar responses were observed at all three trials, where the magnitude of changes in Hb was also almost the same. Since he was very scared, he showed increases in deoxy- and t-Hb even when the doll did not appear yet. We also measured two adults to examine whether this lack of response was related to age. They showed increases in oxy-Hb and t-Hb with a decrease in deoxy-Hb (data not shown).

DISCUSSION

The present study demonstrated that even young children cooperatively participated in cognitive studies, when children's motion was not restricted and measurements were performed in an examination room which looked like an ordinary living room. It was also demonstrated that although severe motion restriction was absent, the portable NIRS system could detect task-related hemodynamic changes. In the present study, three children showed increases in oxy-Hb and t-Hb with a decrease in deoxy-Hb during the Stroop test. This suggested that rCBF increased in the right frontal polar cortex, although it was not examined by 3-D MRI which part of the brain was underneath the probe placed on the head surface. The Stroop test is a classic paradigmatic measure of attention and interference (Stroop, 1935; Macleor, 1991). It has been reported that the right frontal polar cortex, which is associated with selective attention, is activated during the Stroop color naming test (Bench et al., 1993; Carter et al., 1995). The fact that no significant changes in Hb oxygenation were observed in two boys could be explained by their poor task performance. However, in two girls the second Stroop test did not cause further changes in Hb oxygenation, which had not returned to the pre-task levels after the cessation of the first trial (Fig. 3A). Factors such as anxiety, confusion, and anticipation of the task are inherent in subjects, unless they get to perform the task successfully by repeating trials. It is conceivable that such emotional factors were mainly responsible for the increase in rCBF observed in these girls. This might also explain the observation that the degree of changes in Hb oxygenation during the second Stroop test was the same as the degree of those during reading in the 6-year-old boy (Fig. 3B). With a careful paradigm design and placing the probe at a proper position, however, it is possible to detect the brain activation specifically associated with attention. A multichannel NIRS system of the present type, which we are now developing, will not only provide information about multiple brain regions but also be useful to find a proper position of the probe.

There are only a few ways of evaluating the cognitive ability of neonates and

younger infants, who cannot speak yet or perform tasks. Changes in facial expressions and physiological parameters such as the heart rate are often used as indicators of cognition in these subjects (Trevarthen, 1998). For example, whether a baby can distinguish the baby's mother from others is judged from the facial expression. In general, the

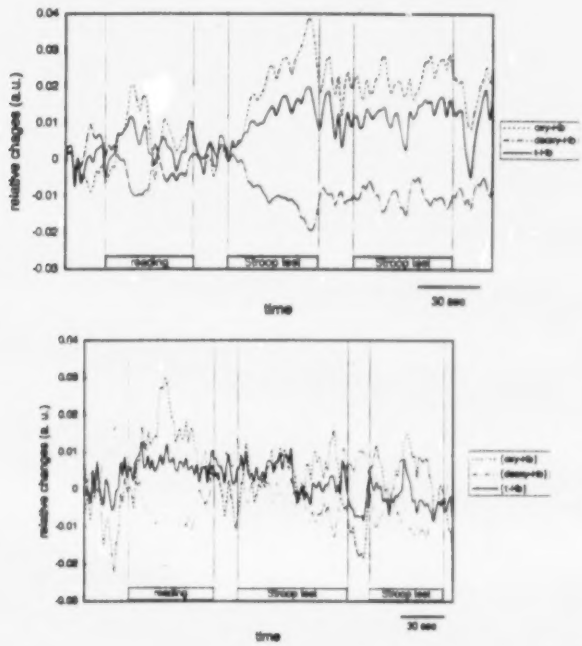

Figure 1 Relative concentration changes in oxygenated (oxy-Hb), deoxygenated (deoxy-Hb), and total hemoglobin (t-Hb) in the right frontal region while a 5-year-old girl (A) and a 6-year-old boy (B) performed the Stroop test. Baselines were selected from resting state, and these values were taken as zero for each signal. Changes from baseline are represented as relative amounts. Upward (plus) and downward (minus) trends show increase and decrease in values, respectively.

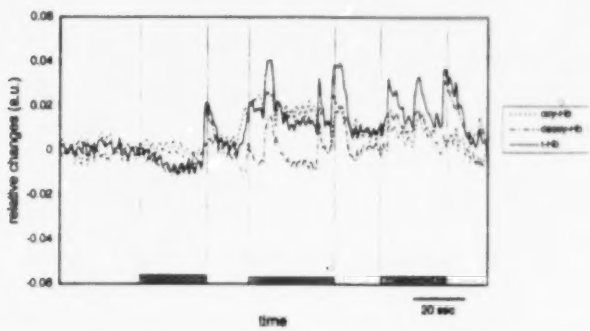

Figure 2 Relative concentration changes in oxy-, deoxy-, and t-Hb while a 3-year-old boy was playing with a jack-in-the-box. The shaded bar denotes time when the handle of the box was being rotated.

cognitive operations are accompanied by emotional changes. It is, thus, expected that by detecting brain activation associated with emotion, the cognitive ability can be objectively evaluated. Emotions are thought to be associated with activation of the medial frontal cortex (Lane et al., 1997). In the present study, however, four kindergarten children did not show any changes in Hb oxygenation while playing with the jack-in-the-box. In contrast, hemodynamic responses were observed in the three-year-old boy and adults. There might be differences in the neural basis of being startled between children of this age and others. Unlike adults, however, this three-year-old boy showed no significant increase in oxy-Hb comapred with those in t-Hb and deoxy-Hb. Recent fMRI and NIRS studies reported a stimulus-related increases in deoxy-Hb in neonates and infants (Born et al., 1998; Meek et al., 1998; Hoshi et al., 2000). However, the degree of increases in deoxy-Hb was smaller than that in oxy-Hb in these previous NIRS studies. At the moment, the absence of significant increases in oxy-Hb in this boy are unexplained.

Although further investigation is required to give valid explanations for these results, it is emphasized that only our system can detect such hemodynamic changes when children are playing. In addition, hemodynamic changes could be monitored in a one-year-old infant when she was playing with her mother. This suggests that the present system has the potential to investigate cognition in neonates and infants by measuring hemodynamic changes related to emotions.

The direction of recent functional mapping studies is toward exploring more precise aspects of brain functions such as the components of working memory (Choen et al., 1997) and the sequence of brain activation (Horwitz et al., 1995). The present reported NIRS system is not suitable for this purpose, but it provides a new direction for functional mapping studies. Our newly developed system will open a window on brain physiology in subjects who have been rarely examined until now.

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CROSS CULTURAL COMPARISON OF EMOTION REGULATION IN JAPANESE AND AMERICAN 11-MONTH-OLD INFANTS

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Abstract

Emotion regulation of 11-month-old American and Japanese infants was compared. Infants' responses to several emotion eliciting conditions were observed in the laboratories. Results showed that Japanese infants behaved less autonomously and were more dependent on their mothers than the American infants, especially during and after stressful conditions. These differences were interpreted in relation with differences in early emotional socialization, parental beliefs and childrearing goals in Japanese and American societies.

Key Words: emotion regulation, lab observation, emotional socialization, parental beliefs, cross cultural comparison

It has been suggested that infants may develop emotion regulation through relational context with caregiver (e.g. Bridges & Grolnick, 1995; Cassidy, 1994; Demos, 1986; Kopp, 1989). Many literatures on infant-caregiver interactions in cross-cultural contexts have documented that there were wide ranges of qualitative differences. If qualitative aspects of infant-caregiver interactions influenced infants' emotion regulation, we can expect that the emotion regulation would be influenced by culture. According to Campos and his coworkers (Campos, Campos & Barrett, 1989; Campos, Mumme, Kermonian & Campos, 1994; Saarni, Mumme & Campos, 1998), emotion regulation should be understood as relational in its nature. In their theoretical framework, culture is one of the important determinants of the nature of emotion regulation. However, there were few

studies on emotion regulation in cross-cultural contexts.

Campos and his coworkers have compared infants' emotion expressions between Asians (Japanese and Chinese) and European American (Camras, Oster, Campos, Campos, Ujiie, Miyake, Wang & Meng, 1998; Camras, Oster, Campos, Miyake & Bradshaw, 1992). However because they mainly compared facial expressions using BabyFACS, an anatomically based coding system, they did not find any evidence on cross-cultural differences of emotion regulation. In this report, infants' emotion regulations were compared between Japanese and European American sample.

Many researchers have done cross-cultural studies on infant-mother interaction between Japanese and American sample (e.g. Caudille & Weinstein, 1969; Fogel, Stevenson and Messinger, 1982: Fogel, Toda & Kawai, 1988; Lebra, 1976; Miyake, Campos, Bradshaw & Kagan, 1986). Some Japanese researchers have insisted that Japanese mothers are indulgent toward their children and less concerned with fostering autonomy and independence (Azuma, 1994; Doi, 1973; Ujiie, 1997; Tsuneyosi, 1992). In contrast, American researchers have believed that autonomy and independence are one of central value in American culture (e.g. Bellah, Madsen, Sullivan, Swidler & Tipton, 1991). American mothers and researchers seemed to share the belief that parents should foster their infants' autonomy and independence through everyday socialization practices to infants' negative emotions (Demos, 1986; Kopp, 1989; Wenar, 1982; Zumbahlen, Koch & Pyevich, 1998).

Recently researchers have examined behavioral strategies to regulate emotion such as active avoidance, orientation toward caregiver, approach/withdrawal, attempts to control the situation, self-stimulation, and attention allocation (e.g. Braungart-Rieker, Garwood, Powers, & Notaro, 1998; Bridges, Grolnick, & Connell, 1997; Buss & Goldsmith, 1998; Kogan & Carter, 1996; Stifter & Braungart, 1995). According to Ginino & Tronick (1988), these behaviors could be classified into two comprehensive categories: Other-directed regulatory behaviors and self-directed-behaviors. Other-directed regulatory behaviors refer to those affective displays through which the infant cues the mother in order that she may aid or supplement the infant's organizational goals. Self-directed regulatory behaviors refer to the infant's own coping strategies to control his or her own affective state. The classification based the directions of behaviors would be critical perspective to compare emotional behaviors between Japan and the United States. Thompson (1994) discussed that American parents have fairly defined expectations that the child should develop capabilities for the self-management of emotion. American mothers may be recommended to give infants opportunities for own efforts of emotion regulation and reinforce their efforts (Brazelton, 1983; Spock, 1968), but they may underestimate other-directed efforts because the other-directed efforts may be recognized as passive, dependent and immature. American researchers shared the same frame of reference. For example, Demos (1986) described of short life history of Cathy who failed to develop self-regulatory ability until 8 months because her mother's over-nursing and over-involvement. According to Demos (1986), her mother nursed so quickly when Cathy expressed even mild fussy states. On the contrary, Japanese mothers tend to have so strong attachment to their infants. As described by many researchers, Japanese mothers try to minimize infant crying and they intervene so quickly to infants' distress

(e. g. Doi, 1973; Lebra, 1976; Miyake et al., 1986). It is quite natural and desirable for Japanese people that infants depend on their caregivers when they are in distress. For Japanese mothers, sensitivity to read infants' affective display is very important. The other-directed regulatory behaviors may not be recognized as immature in Japan. Rather Japanese mothers may encourage infants' efforts to elaborate other-directed regulatory behaviors.

Thus it was expected that infants' emotion regulation would be different between Japanese and European American sample. It was hypothesized that Japanese infants would behave in more dependent ways when they experienced negative emotion, on the contrary European American infants would behave in more autonomous and independent ways.

METHOD

Participants

The participants were 11-month-old Japanese infants from Fukushima (n=20, 9 boys and 11 girls) and American infants from Berkeley, California (n=21, 13 boys and 8 girls). Participants were recruited from urban neighborhoods surrounding the universities at which data collection took place (Fukushima University, Fukushima city, Japan and University of California, Berkeley, California, USA). They were all healthy infants. The infants' families were unpaid and took part on a voluntary basis.

Procedures

Observations were conducted after infants were exposed in stressful episodes, arm restraint and growling gorilla presentation (cf. Camras, Oster, Campos, Campos, Ujiie, Miyake, Wang & Meng, 1998 on detailed procedures). During both procedures, the infants were seated in a high chair and mothers sat in a chair on the infant's right side facing perpendicular to the infant. Mothers were instructed to remain passive during stimulus presentation. The coding began immediately upon the termination of the stressful episodes (post stressful episodes) and varied for each infant, depending on the lengths of the infant's crying episode. Although mothers instructed to restrain from responding to infants' behaviors for a few seconds after removal of gorilla and freeing of the arms, they could respond and try to soothe for their infants. Then it could be observed infants' negative emotion regulation in the relational context with their mothers during post stressful episodes.

Coding

Infants' crying was coded every second. According to these data, latency of first ceasing of crying and duration of crying from mothers' approach/touch with infants were computed. Infants' behaviors toward mothers were rated into 1(observed) or 0(not observed): Seeking proximal/contact with mothers, crying directed to mothers, changing tone of crying, and crying included "amae" tone. Mothers' approaching/touching with infants was also coded every second.

Two trained coders independently rated the videotapes. Inter-rater agreement on crying was 95%; agreement of infants' seeking of proximal/contact with mothers was

100% ; crying directed to mothers was 100% ; agreement of changing tone of crying was 85% ; agreement of crying included "amae" tone was 94% ; agreement of mothers' approaching/touching with infants was 98%.

RESULTS

There was not statistical difference in quantitative aspects of crying. The percentages of infants who continued crying after removal of gorilla and freeing of the arms were almost the same in both samples. Infants who did not cry in stressful episodes or stopped crying immediately after removal of gorilla and freeing of the arms were 14 (8 in growling gorilla presentation and 6 in arm restraint) in Japanese and 17 (11 in growling gorilla presentation and 7 in arm restraint) in American as shown in Table 1.

The mean latency of infants' cessation of crying after mothers' approach/touch with infants was computed. As shown in Table 2, there was no significant difference between two samples. Many infants ceased crying by mothers' approaches/touches, but the cessations were temporary because they frequently resumed to cry. Thus mean duration of infants' crying after mothers' approaches/touches with infants was computed. As shown in Table 3, American infants cried longer than Japanese infants did in arm restraint procedure. On the contrary in growling gorilla procedure, Japanese infants cried longer than American infants did. But these differences did not reach significant level using ANOVA.

However, qualitatively there were obvious differences between two samples as shown in Table 4. The figures in Table 4 were numbers of infants who continued crying after removal of gorilla and freeing of the arms, the denominator was 26 for Japanese sample and 23 for American sample.

The numbers of infants who tried to retain proximity/contact with mothers during

Table 1 Numbers of crying in post stressor eposodes.

	Variables	Growling Gorilla	Arm Restraint	Total
Japanese infants	No cried/immediately recovered	8	6	14
	Ceased crying immediately but cried again soon	5	5	10
	Continued of crying	7	9	16
American infants	No cried/immediately recovered	11	7	18
	Ceased crying immediately but cried again soon	5	5	10
	Continued of crying	4	9	13

Table 2 Latency of first cessation of crying from when mothers approached/touched with infants.

	Growling Gorilla	Arm Restraint	Total
Japanese infants	7.83 (6.9) N=12	5.85 (5.84) N=14	6.46 (6.48) N=26
American Infants	5.28 (4.56) N=7	6.3 (6.3) N=13	6.25 (5.8) N=20[a]

Note. a) Three were excluded because mothers did not approach.
The numbers in parenthesis are SD.

Table 3 Duration of crying from when mothers approached/touched with infants.

	Growling Gorilla	Arm Restraint	Total
Japanese infants	24.0 (14.6) N=12	9.35 (7.12) N=14	16.12 (13.38) N=26
American Infants	14.14 (11.86) N=7	14.46 (14.05) N=13	14.35 (13.32) N=20[a]

Note. a) Three were excluded because mothers did not approach.
The numbers in parenthesis are SD.

Table 4 Numbers of those who displayed behavior categories toward mothers.

	Proximal/contact seeking	Crying directed to mothers	Changing tone of crying	Crying included "amae" tone
Japanese infants	19 (73.1%)	24 (92.3%)	24 (92.3%)	19 (73.1%)
American infants	6 (26.1%)	14 (60.9%)	11 (47.8%)	4 (17.4%)

post stressor episodes were significantly different between two samples, 19 in Japanese sample and 6 in American sample (x^2 =10.78, df=1, p<.01). Japanese infants showed leaning and/or reaching toward mothers frequently than American infants. Japanese infants sometimes held up their hands just like waiting to be picked up by their mothers, in contrast these behaviors did not observed in American sample. The numbers of infants who directed crying toward mothers during post stressor episodes were significantly different between two samples, 24 in Japanese sample and 14 in American sample (x^2=6.93, df=1, p<.01). The numbers of infants who changed their tone of crying during post stressor episodes were significantly different between two samples, 24 in Japanese sample and 11 in American sample (x^2=11.8, df=1, p<.01). In Japanese sample, some infants changed their tone of crying such as pitches and strength of their crying in complex ways. Some infants strengthened crying when their mothers tried to soothe them. Some infants ceased to cry immediately after stressful episodes, but when their mothers approached and contacted with and when they talked to infants, the infants showed fussing or crying. The numbers of infants who showed crying including "amae" tone were significantly different between two samples, 19 in Japanese sample and 4 in American sample (x^2=15.19, df=1, p<.01).

There was no significant difference in mothers' behaviors between two samples. Almost all mothers approached or touched infants after the experimenters told them that procedure was over. All Japanese mothers and eighty-seven percent of American mothers whose infants continued crying after removal of gorilla and freeing of the arms approached or touched their infants. The mean latencies of mothers' approach/touch with infants were shown in Table 5, and there was also no significant difference between two samples.

But the ways of approach/touch were different between two samples. Japanese mothers tended to approach to infants nearer than American mothers did. American mothers tended to contact only by hand, and they seldom moved their bodies close to

Table 5 Latency of mothers' first approaches/touches with infants.

	Growling Gorilla	Arm Restraint	Total
Japanese infants	2.2 (1.07) N=12	4.0 (2.53) N=14	3.15 (2.2) N=26
American Infants	1.57 (.49) N=7	2.13 (2.96) N=13	1.95 (2.48) N=20

Note. The numbers in parenthesis are SD.

infants. Japanese mothers actively initiated and organized the interactive processes in order to soothe infants' negative emotions.

DISCUSSION

The results of this study clearly supported hypothesis. Japanese infants behaved less autonomous and more dependent on their mothers than American infants did. During post stressful episodes, the majority of Japanese infants sought proximity and contact with their mothers. Some of them showed dependent and passive strategies, they held up their hands just like waiting to be picked up by their mothers. In contrast these behaviors did not observed in American sample. Almost all of Japanese infants directed crying toward their mothers. When the infants directed crying toward mothers, they changed tone of crying such as pitches and strength in very complex ways except only two. Moreover, very frequently the crying episodes of Japanese infants had "amae" tone. They looked like to appeal to mothers that they were in trouble and in need to be rescued urgently by mothers.

The infants' behaviors observed in this study would be interpretable in the line of literatures on early emotional socialization in Japanese culture (Caudille & Weinstein, 1969; Lebra, 1976; Miyake, Campos, Bradshaw & Kagan, 1986) and parental beliefs and goals (Azuma, 1994; Doi, 1973; Ujiie, 1997; Tsuneyoshi, 1992). According to these studies, Japanese mothers may have keen sensitivity to infants' signals and also feel heavy responsibility to infants' wellbeing.

If Japanese infants' behaviors observed in this study represented their behaviors in daily interaction, their dependent behaviors including expressions of "amae" would be an effective strategy to regulate their negative emotion. Japanese infants seemed to use their mothers as external regulators of their own negative emotions. At first, they regulate their expressions of negative emotions. They do not try to inhibit their own negative emotions. Instead, they modulate expressions of negative emotion so that they can tell the messages to mothers effectively that they are in need to be rescued urgently by mothers. They express negative emotions by changing crying patterns with "amae" tone. Second, when infants express negative emotions in ways mentioned above, Japanese mothers feel an urge to pick up infants and to relieve infants by holding tightly or keeping very near positions. Thus Japanese style of emotion regulation would be "relational emotion regulation".

In contrast, American infants seemed to develop simpler strategies for regulation of negative emotions. To regulate negative emotions, American infants depended on their mothers less than Japanese infants did. In fact they frequently showed referencing and

vocalizations toward their mothers in stressful episodes, but they seldom referred to their mothers and sought proximity/contact with their mothers during post stressful episodes. It was rare for American infants to change their crying pattern directed toward mothers with "amae" tone. American infants did not use "relational emotion regulation". They seemed to be autonomous and independent from their mothers as compared with Japanese infants.

In this study, the analysis using emotion regulation strategies was not done. But the results of this study could be comparable to discussions on emotion regulation strategies. Japanese infants showed mother-directed crying with changing of tone and "amae" tone so frequently than American infants. These results could be interpreted that Japanese infants used other-directed regulatory behaviors. On the contrary, American infants did not use other-directed regulatory behaviors. But there was no evidence to show that American infants used self-directed regulatory behaviors, although they seemed to behave more autonomously than Japanese infants.

American mothers neither moved close to the babies nor stayed beside infants for a long period. They looked like to inhibit excessive involvement, they tended to work on infants by some distal mode of interaction rather than actively seeking or keeping proximity with infants. These facts were consistent with American belief that parents should foster infants' autonomy and independence (Demos, 1986; Kopp, 1989; Wenar, 1982; Zumbahlen et al., 1998).

From an American point of view, mothers' excessive involvement in infants' negative emotion is not recommended because it may spoil infants' autonomy and independence (cf. Demos, 1986; Kopp, 1989). In contrast, Japanese mothers are advised to involve infants deeply because it may contribute to infants' well being (e. g. Matsuda, 1996). The facts described in this study may be consistent with background belief systems embedded in respective cultures. The results of this study would support Campos' functionalist approach to emotion and emotion regulation (Campos et al., 1989, 1994; Saarni et al., 1998).

In summary, the results of this study suggested a cultural variability of emotion regulation. Cultural difference between Japanese and European American samples would be attributable to infant-mother interaction context influenced by background belief on the nature of infant and parental role in socialization. Two kinds of emotion regulation strategies were documented. One is a relational emotion regulation, which has been observed among Japanese infants. Japanese infants seemed to use their mothers as external regulators of their own negative emotions and they would develop in direction to modulate expressions of negative emotion so that they could tell their messages to their mothers effectively. The other is the autonomous emotion regulation, which has been observed among American infants.

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THE BASIC STRUCTURE OF METACOMMUNICATION IN INTERSUBJECTIVE FUN-INTERACTIONS BETWEEN MOTHERS AND INFANTS: ANALYSIS OF TWO CONTRASTING CASES

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Abstract

In this study, the basic factor regulating successful metacommunication in mother-infant fun-interaction was explored. As fun-interaction contains maternal pretending actions, it was assumed that the infant has to develop metacommunication skills to identify his/her mother's play-intention in order to respond with laughter. To collect video-data for this study, mothers were asked to keep a 'Video Diary' every week. For this report, two infants, one who laughed most frequently and one who was distressed most often were selected from 19 infants who were participants of an original project. The observation covered the period of infancy from 6 to 12 months of age. From the collected video-data, the time-point when laugh/distress was observed was identified as the 5 second base-point segmeut and a 45-second-time-sequence consisting of four 5-second segments before, at and after the base-point and the base point itself was defined as an episode. Frequency of pretending/literal actions of the mothers engaged, coordinated emotional expressions between the children and their mothers, and their voluntariness were analyzed. Results showed 1) the mother of the most laughed infant used pretended actions more often than the other, 2) her laugh-evoking actions showed an elaborated fluctuation pattern shifting her actions from pretense to seriousness or conversely at the base-point, 3) it was more developed with her child age. It was suggested that the individual style in infant's metacommunication may be fostered depending on his/her mother's intersubjective selection of action mode.

Key Words: metacommunication, intersubjectivity, fun-interaction, mother-infant, laugh

INTRODUCTION

Presence of a partner in a close relationship serves not only as a resource of sense of security and as a secure base for us to challenge and overcome strange environments as the attachment studies have theorized. It also serves as an agent of our shared enjoyment. According to Izard (1972), we mainly feel enjoyment when a) we can make the loved person happy by means of doing some adventure together, or by our presence; b) we find that his/her concern is to direct us towards joy; c) we share the same experiences with him/her. This tells us that to share positive emotions is fundamental in any love relation as Izard (1991) suggested and that joy experiences in parent-child relations grow into a sense of mutual trust and love toward others. In daily life, it is often observed that

parent-child, siblings, good friends, lovers, or couples enjoy "fun-interactions". Fun-interaction is laugh-making interaction intending to share enjoyment through humor, joking, pleasantries, comical acts, clowning, teasing, exaggerated gestures and voices, and the like. Fun-interaction is also a distinctive feature of close relations. Dunn's (1988) observation described lively how skillfully two year-old children engage in fun-interactions with their mothers and their sibling as humorists, a tease, and a joke-maker.

However, researchers seem unconcerned with this subtle, vague, discursive, and irrational human activity. Allport (1959) strikingly called the negative attitudes 'the tenderness taboo' --which reflects suspicion significance of studying such subtle voluntary actions as humor, love, laugh, or ecstasy-- almost a half century ago. It may be generally agreed that positive emotion is one of central features of human relationship. In spite of that, the mainstream of emotional studies has focused on rather discrete affects (cf. Sroufe, 1995), or understanding (cf. Saarni & Harris, 1989) of individuals than emotion in inter-personal interaction. For instance, Izard (1993) wrote her speculation that one of the first affective-cognitive structures can be organized by the associative bond of enjoyment and the image of the mother's face. This idea aimed to demonstrate how the initial structure of infants becomes developmentally a complex nexus of affect-cognition, which constitutes the mental representation of an attachment figure. Although this proposal was itself worth studying, in the process of the consideration, she failed counting two further important facts. First, both infant and mother have emotions and they enjoy exchanges of their emotional expressions mutually. Second, therefore, emotional expression to the partner or the attachment figure in an interaction is a communicative display. Emotional expressions are not isolated personal activities, but gain their significance in a frame of emotional communication/interaction with the partner. In this sense, emotional communication is intersubjective (Trevarthen, 1979) and metacommunication underlies it (Bateson, 1956).

In this article, therefore, fun-interaction is viewed as one aspect of emotional communication and is based on metacommunication to share feelings of intimacy. The basic question to be answered here is whether, when and how infants can understand an undercover message conveyed by such a thing as mothers' laughter-evoking extraordinary attempt at a funny, comical, exaggerated teasing, or tickling act. For this purpose, it is explored from a viewpoint of metacommunication what the fundamental structure is and what factor primarily regulates fun-interaction between mother and child. As mother's acts in fun-interaction are somehow unusual or extraordinary and may contain pretense or deception, it is assumed that infants do not respond with laughter unless they develop skills to extract the mother's play-intention from them. This point was the issue of "an old dispute" between McGhee (1977) and Pien and Rothbart (1980). In the discussion on the function of incongruity as a producer of laughter, McGhee insisted from the viewpoint of the Piaget's concept of reality assimilation that the prerequisite condition to laugh at a funny thing is attainment of cognitive congruity. He maintained that a child has to pre-acquire a notion of how "things should be in nature" to find the funny aspect of things. Thus, he denied the possibility for young infants who have not yet developed this notion to express laughter about a funny thing. On the other hand, Pien and Rothbart argued the possibility of infant's laughter at humorous objects because laughter is raised

at a phase shifted from excitation aroused by an unexpected event or surprise into relaxation to indicate feeling security in the excitation-relaxation cycle. Then, according to their insistence, even a mother of a four month-old infant can draw laughter from her baby by means of this incongruity strategy. In their idea, the required condition to evoke laughter is not the infant's attainment of cognitive schema, but his/her excitement and consequent mother's laughter or something to express security toward her baby. Sroufe and Wunsch (1972) also investigated empirically a relation between types of stimuli (auditory stimulation, intrusive tactile stimulus, social games, and socio-visual events, i. e. unnatural acts) and elicited laughter in infants from 4 to 12 months. The results demonstrated that in older infants, especially from 10 to 12 months, laughter was elicited by socio-cognitive stimuli while in younger infants it was done by physical stimulus. This study provided evidence that there was a developmental shift in the effective elicitors of laughter from provocative stimulus to cognitive incongruity in the second half of the first year of life. The findings suggested that laughter is a product of a sharp tension fluctuation, which is achieved by developmental sophistication of cognitive ability to assimilate novel experiences. Along this line, Sroufe (1979) also proposed a developmental postulation that infants around 9 months of age are "affectionate beings" because they evaluate events affectionately by applying cognitive incongruity between anticipation and consequence, and their affection is aroused by the event. As a result, the event is assimilated into a schema of good or bad things with affective tone depending on the context. Thus, cognitive incongruity is the central factor of those studies.

Although those studies demonstrated a basic structure of laughter, they obviously missed the crucial point that playful mother-child interaction is intersubjective. Göncü (1993) attempted to theoretically analyze social pretend play in peer relations from a viewpoint of intersubjectivity and concluded that intersubjectivity develops simultaneously on three panels ; sharing emotional experiences, metacommunication of being in pretense, and communicative devices. This consideration suggested that intersubjectivity and metacommunication are inseparable (Trevarthen, 1988, 1993), although Bateson's (1956) original definition ignored this point. Göncü (1993), further raised a need to examine that children are motivated to share their worlds in pretend play from very early on in life. However, previous studies on peer play in younger children have been done without inquiring origins of metacommunication (Bretherton & Beeghly, 1986). This may mostly come from the ambiguity of Bateson's (1956) original definition because he did not show the structure of metacommunication, but described his observation of monkey's play fighting at a zoo anecdotally. He did not consider if it was universal beyond species or not. In his book with the catch phrase "the spirit of the Batesonian tradition", Stolnik (1989) also wrote that the two-month-old infant is involved in this very high level of logical abstraction (metamessage), as are all baby animals. This statement denotes clearly that he regarded metamessage (metacommunication) as an innate communicative function. Therefore, we still need to try to refine the concept of metacommunication. Stern's (1986) theory that metamessages are carried by various temporal attunements seems to suggest the direction in which we move. In this sense, fun-interaction may be one ideal phenomenon to examine intersubjective pretense and its metacommunication because in it, both child and mother must be able to "read" the

intersubjectivity mutually as Stern (1986) suggested.

In this study, through comparison of two contrasting boys' emotional expressions in fun-interaction with their mothers, we examine what the primary factor is that enables them to receive maternal intentions to make them laugh.

METHOD

Participants

The participants of this longitudinal study were two boys (Naoya & Kenta) and their mothers. They participated from the children's ages of 6 to 12 months. They were selected from 19 mother-infant pairs who were participants of the "Fun-Interaction in Infancy" project. Naoya was the child who laughed the most frequently, while Kenta was the one who showed the most distress. Both children are Japanese and were living with their parents in a megalopolis in Japan. Both mothers were householders.

Procedures

Both mothers were asked to videotape their playful interaction with the child at home by themselves for the sake of their own commemoration of the child's development at each month of age. After finishing this study, copies of the recorded videotapes were given to them. This methodology is called "Video Diary of Child Development" (Nakano, 2000). This methodology was invented because usually people engage in fun-interaction only in a relaxed secure situation, so it is very hard to observe it in an experimentally structured situation. Mothers were instructed to stop recording whenever the child was resistive and resume it another day. However, the total duration of each recording required at least 30 minutes. Naoya's tapes were successively collected through all 6 to 12 months of age, but Kenta's mother missed recording at nine and 11 months of age. So, in this study, data analysis was executed on the recorded materials from 6, 7, 8, 10, and 12 months of age.

Coding of Observational Data

Episodes. First, the time point (base point) that the child started to laugh, induced laughter or distress to his mother's act, or the mother started to tickle her child was identified on the video materials for each month. Then, to examine the antecedent and the consequent of behavior, a time point of 20 seconds before, at and after the base point and the 5 second base point itself was decided (total 45 minute period) and extracted as an Episode.

Coding categories and reliability. Each episode was divided into nine 5-second-time-segments. Both mother's and child's acts within each segment were coded into categories which are as follows.

Mother

- Action Mode
  - Literal
  - Pretense
  - Serious
- Contingent Emotional Expression
  - Smile
  - Laugh

Child

- Emotional Response
  - Smile
  - Induced Smile
  - Laugh
  - Distress
- Voluntariness
  - Passive
  - Coordinate
  - Initiate

These are exhaustive and mutually exclusive within each dimension. Two coders independently coded all videotapes received from both families and the percent agreement for the coding was as follows: Identification of episodes 100 %, mothers' acts 92.1 % (90.2 to 100%), infant's acts and responses 86% (77.8 to 96.3%).

Data Transformation and Leveling. The recording time in each month and between Naoya and Kenta was different. So, all data of frequency were recalculated to be frequency per 30 minutes and presented in percentage.

RESULTS AND DISCUSSION

As statistical analysis is still ongoing at the moment, an outline of the main findings is presented here.

General Tendency of Episodes

Figure 1 shows frequency of three types of episodes for both children: Laugh, Induced Laughter, and Distress through the observed months. The results depicts individual differences between both boys' emotional reactions to the maternal attempts to make the child laugh. Clearly, Naoya expressed laughter more often and rarely showed distress, while Kenta was characterized by both expressions of joy and distress, especially a high frequency of distress at 7 & 8 months of age. As both mothers recorded playful interactions (at least from the mother's viewpoint), the most plausible child's reaction

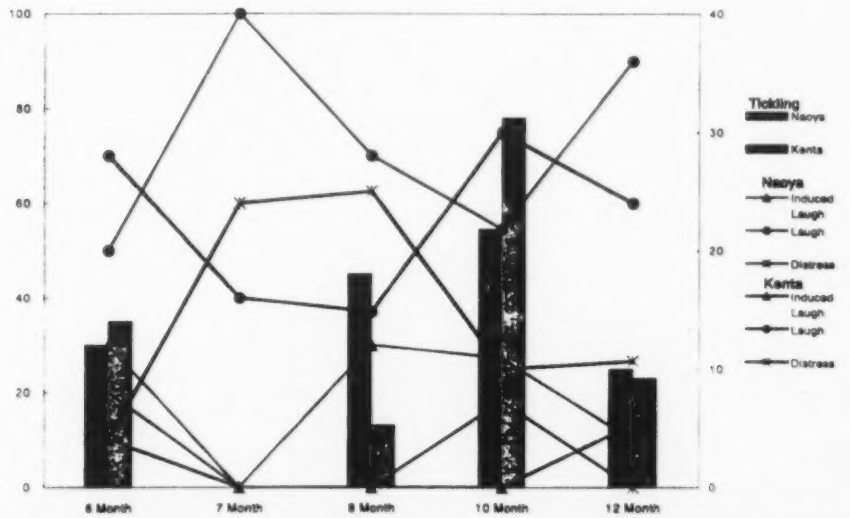

Figure 1 Comparison of the two children in frequency of episodes in three types of emotional responses and in mother's frequency of tickling.

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was undoubtebly laughter, not distress. Then it is easily understood that the child's distress indicates their failure in sharing playfulness which their mother intended through metacommunication. Therefore, Kenta and his mother seem to have had some difficulty in metacommunication through the observed period, as compared with Naoya and his mother.

The results of maternal tickling in Figure 1 also show their individual differences in the mother-child relationship. Naoya's mother employed tickling as if she expected to compensate for less occurrence of laugh when his response of laughter was decreased. Increase of his induced laughter also shows this tendency and implies his mother's motivation to share fun with him. In contrast, Kenta's mother's frequency of tickling was likely to co-occur with a relatively high frequency of her son's laughter. This may indicate her successful attempts of tickling. However, higher frequency of his distress also suggests that the mother's tickling may be, so to speak, a double-edged sword. Tickling seems to have had a different function between the pairs.

In the following section, we examine what factor produced individual difference in success and failure in metacommunication of playfulness between two mother-child pairs.

Relationship between Mother's Action Mode and Child's Emotion Responses

Figures 2 A to E show how the mother's pretense/literal acts affected her child's successful engagement in metacommunication. It manifests that Naoya's mother used pretended acts more often than Kenta's mother did, except at 7 months of age. Considering this difference, combined with the difference in the child's emotional expressions, it can be postulated that the possible basic factor to enable metacommunication of playfulness underlying mother's humorous, comical acts or teasing is pretense. This result also demonstrates that infants can "read" funniness of pretense from earlier months of life than previous studies (McGhee, 1977; Sroufe & Wunsch, 1972) have shown.

Relationship between Mother's Expressions and Child's Emotion Responses

In the above result, the reason why Naoya expressed laughter more than Kenta may be because his mother also laughed contingent with her acts and he may have attuned to the expressions. Then, relationship between the mother's expressions contingent with her acts and the child's emotional responses was examined. The results are presented in Fig. 3 A to E. Interestingly, in contrary to the expectation, Kenta's mother laughed more frequently than Naoya's mother did. Her laughter was often expressed around the base point, when Kenta also expressed laughter or distress. In contrast, Naoya's mother continuously expressed smiling and only occasionally laughed. Therefore, it can be concluded that the mother's expression is not a candidate of control factor of metacommunication.

Child's Voluntariness

In the interaction with the mother, the tendency of how both children participated voluntarily was examined because the child's voluntariness, i.e. degree of active involvement in the interaction, may have affected sensibility of metacommunication. However, as seen in Figure 4 both children showed rather similar tendencies through out the observed

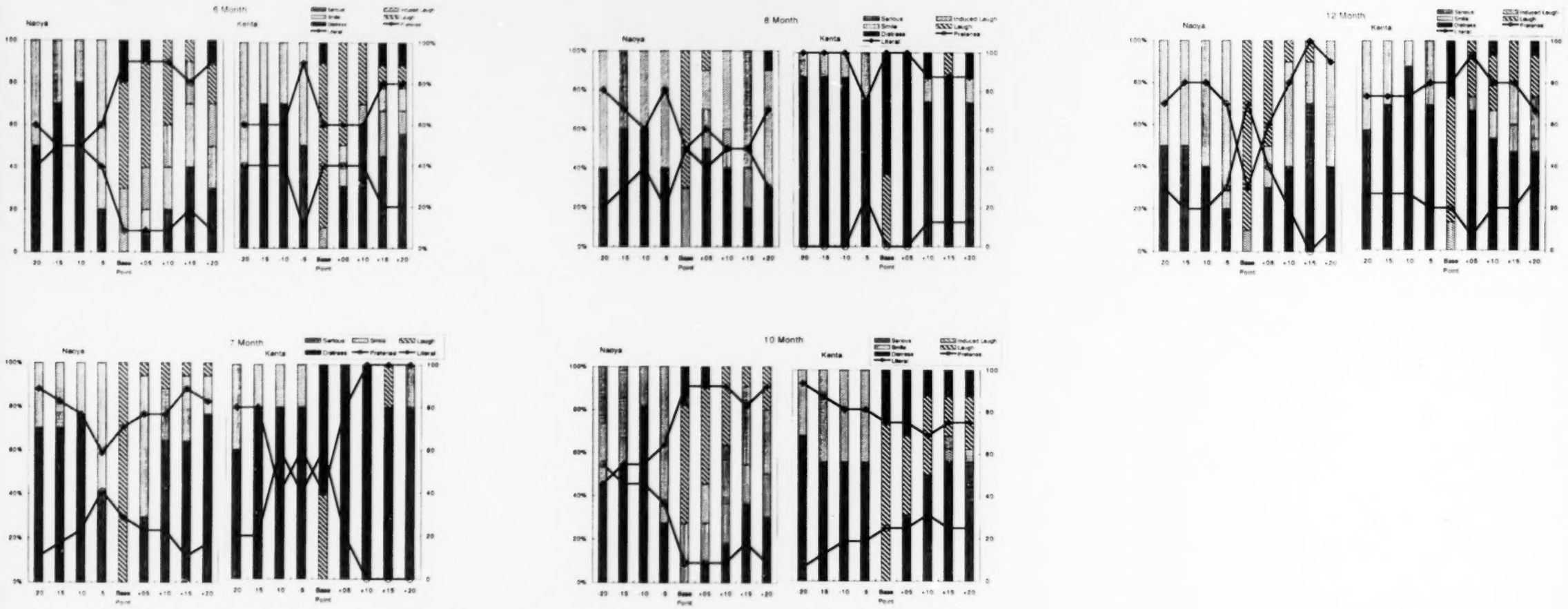

Figure 2 Correlation between frequency of pretending/literal actions that the mothers of the two children engaged in and emotional expressions in their responses at each time segment in an episode of each observed month.

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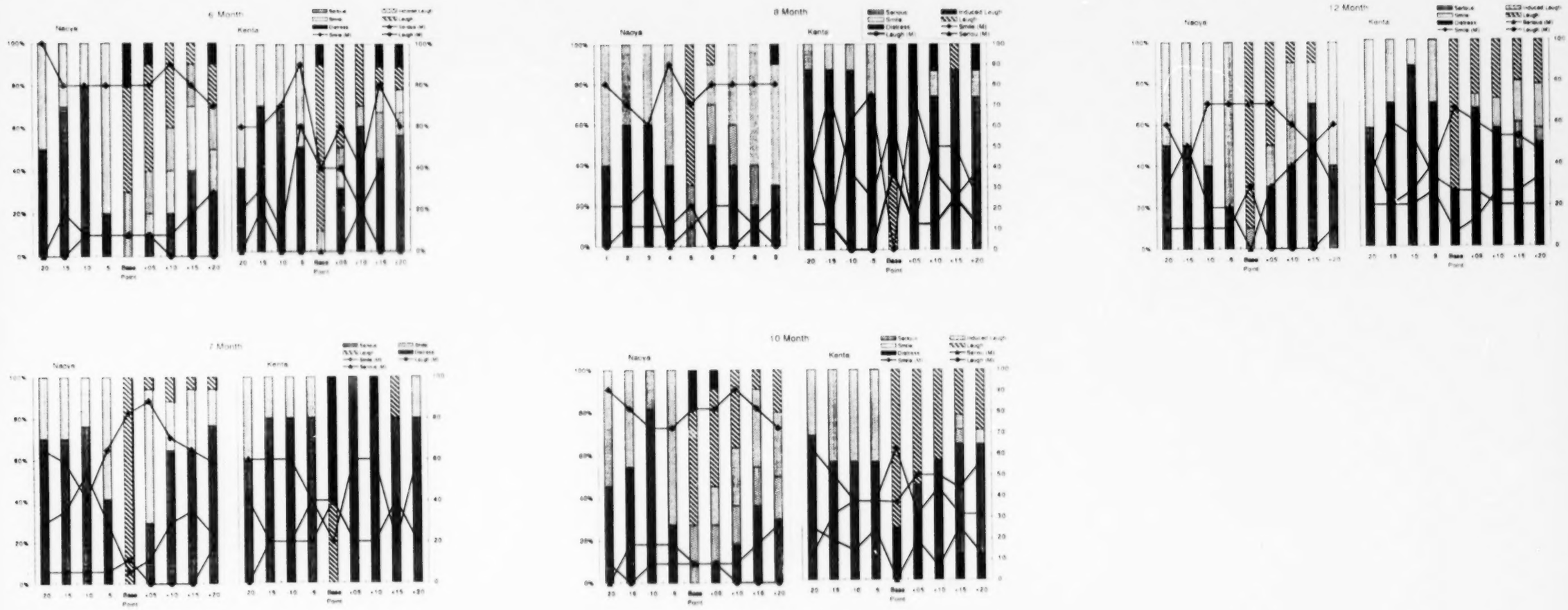

Figure 3 Correlation between emotional expressions of the mothers of the two children contingent to their laugh-evoking actions and emotional expressions in the children's responses at each time segment in an episode of each observed month

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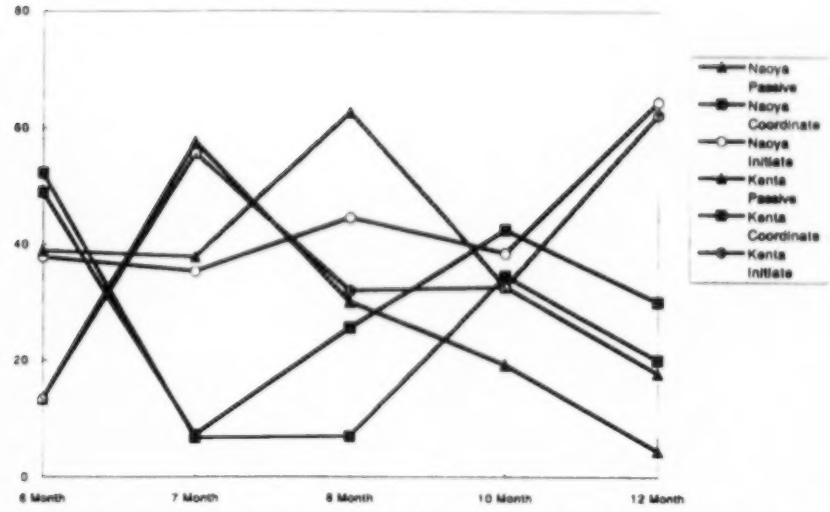

Figure 4 Comparison of developmental change in three types of voluntariness between the two children.

period. From 10 months of age, both children became more initiative and less passive. This tendency can account for a relatively high frequency of laughter at 10 and 12 months of age presented in Figure 1 ; however, this is not plausible to be the accountable factor of the individual difference between both mother-child pairs in metacommunication.

Mother's Temporal Action Pattern

As many previous studies (McGhee, 1977 ; Pien & Rothbart, 1980 ; Sroufe, 1979, 1995, Sroufe & Wusch, 1972) have noticed the special stimuli pattern for eliciting laughter, the temporal fashion of the mother's action such as a steep, sharp tension fluctuation may have been effective to make the child laugh. Thus, the degree of fluctuation from one time-point to the next time-point (lag 1 time-point) was calculated. As Figure 5 illustrates, there is a difference in the interaction strategy between the two mothers. Naoya's mother was using an elaborate strategy of fluctuation effective at the base-point. In other words, she shifted expertly her action mode from pretense to seriousness or conversely at this point. In contrast, the pattern of Kenta's mother was not so organized at the base-point. Their changing pattern as the children developed also showed a contrast between them. While Naoya's mother was elaborating the fluctuation strategy more and more to be steep and intensive, Kenta's mother moved in the opposite direction to use more moderate or plain strategies. Thus, they each developed individual ways of mother-child interaction during infancy.

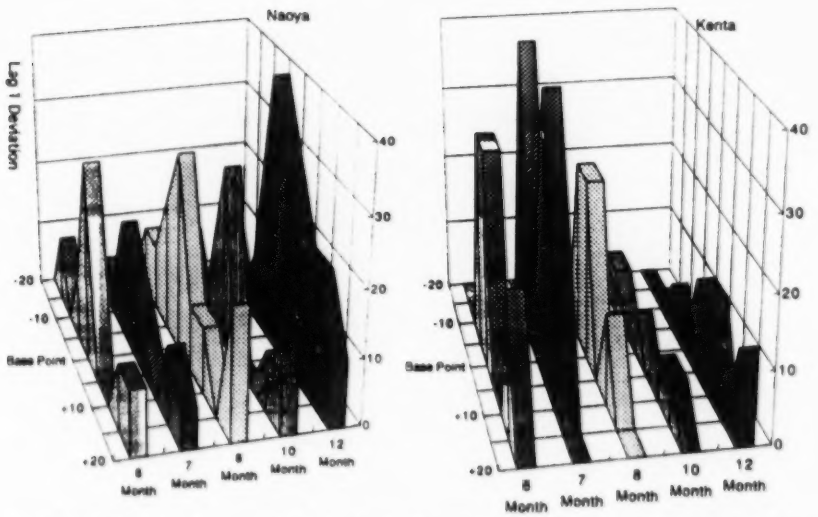

Figure 5 Longitudinal developmental change in the fluctuation pattern between frequency of pretending/serious actions at one time-segment and the fluctuation pattern at the next segment that the mothers of the two children showed.

CONCLUSION

As results presented in Figures 1 and 4 show, at their first birthday, both Naoya and Kenta became infants who often laugh at their mothers' acts and spontaneously involve in fun-interaction with the in mothers. However, it is concluded that they participated in the interaction each engaging in their own style of metacommunication with their mothers as well as the mothers developing their interaction styles to meet with the emotional reactions of their children. This finding seems to be worthy of further studies to examine the direction of development and individual difference of metacommunication.

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